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SYNOPSIS OF ROSENBUSCH'S NEW SCHEME FOR THE CLASSIFICATION OF MASSIVE ROCKS.

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III. THE EFFUSIVE ROCKS.

THE effusive or volcanic rocks are those which flowed out upon a land surface and there solidified. For most of the intrusive rocks there are corresponding effusive ones, as might naturally be expected, but these latter are usually slightly more acid than the former.

The characteristic structure for this group is the porphyritic. The cooling of the effusive rocks takes place in two stages, (1) while the rock mass is still within the depths of the earth—the *intratellurial* period, and (2) after it has flowed out upon the surface—the *effusive* period. During the first stage certain minerals crystallize from the magma. These are idiomorphically developed, and become the porphyritic crystals in a ground mass which is produced by the cooling of the residual magma after it has reached the surface. As the cooling during the effusive period is comparatively rapid, there is a tendency for the ground mass of this group of rocks to approach the glassy condition. When, however, the cooling in the effusive period takes place slowly enough to allow of complete crystallization, a holocrystalline ground mass results and the rock assumes a *holocrystalline-porphyritic* structure.

When the cooling is rapid the ground mass is glassy, and the rock is said to have a *vitrophyric* structure. Between these two extremes are other rocks whose ground mass is composed partly of crystalline minerals and partly of glass. This is the *hypocrystalline-porphyritic* structure.

The ground mass of the holocrystalline-porphyritic rocks may be so developed as to possess either a hypidiomorphic-, a panidiomorphic- or an allotriomorphic-granular structure.

Since the structure of the older members of the effusive rocks presents features which are different from those presented by the younger ones, it is convenient to separate them into an older and a younger group. The beginning of the Tertiary age seems naturally to be the line of division (in time) between the two groups.

III. A. THE PALÆOVOLCANIC EFFUSIVE ROCKS.

The palæovolcanic division of the effusive rocks is distinguished macroscopically by the lithoidal or stony character of the ground mass of its component members.

It includes a continuous series of rocks corresponding in mineralogical composition to the series composing the intrusive class, and, like this latter, is divided into families in accordance with the nature of the principal constituent minerals.

A. THE QUARTZ–PORPHYRIES.

The quartz porphyries are the old effusive equivalents of the granites. By far the larger portion corresponds in mineralogical composition to the granitites, so that no attempt has been made to subdivide them on mineralogical grounds.

They are porphyritically developed—quartz, orthoclase, biotite, sometimes hornblende and augite occurring in porphyritic crystals. The difference of structure observed in their ground mass affords the basis for their further subdivision.

1. MICROGRANITE, in which the ground mass is a very fine panidiomorphic- or hypidiomorphic-granular combination of quartz and orthoclase.
2. GRANOPHYRE, in which the ground mass is holocrystalline, but is composed of quartz and orthoclase, developed in such a manner as to mutually penetrate each other.
3. FELSOPHYRE, in which the ground mass is so very fine that its components cannot be recognized under the microscope. When carefully examined it appears as an almost isotropic substance with, however, some indications of structure.
4. VITROPHYRE, in which the ground mass is a glass, with or without microlites and devitrification products.
    (A) *pitchstone porphyry* contains porphyritic crystals, recognizable by the naked eye.
    (B) *pitchstone* contains no macroscopic porphyritic crystals.

B. THE QUARTZLESS PORPHYRIES.

The quartzless porphyries are the old effusive equivalents of the syenites. They are porphyritically developed with an alkaline feldspar and one or more of the iron-bearing silicates as porphyritic crystals. Their ground mass is holocrystalline, consisting principally of feldspar and quartz. They are subdivided into:—

1. ORTHOPHYRE, containing a monoclinic alkaline feldspar among the porphyritic crystals.
    - (A) *biotite-orthophyre,* containing in addition porphyritic biotite.
    - (B) *amphibole-orthophyre,* with amphibole in porphyritic crystals.
    - (C) *augite-orthophyre,* with augite as the prominent porphyritic constituent.
2. RHOMBIC-PORPHYRY. This rock is characterized by the rhomboidal shape of its porphyritic feldspars, which belong to the anorthoclase series.
3. KERATOPHYRES, contains a sodium-rich alkaline feldspar, and sometimes quartz, porphyritically developed. Among the bisilicates a malacolitic augite is most prominent. The keratophyres include:—
    - (A) *keratophyre,* in which are no porphyritic quartzes.
    - (B) *quartz-keratophyre,* in which quartz is porphyritically developed.

C. THE PORPHYRITES.

The porphyrites correspond to the diorites of the intrusive class. They are characterized by the possession of plagioclase and hornblende, together with a dark mica or pyroxene, and sometimes quartz, as their principal components. They are porphyritic, but their ground mass may be either holocrystalline, felsitic or amorphous in character. They are divided in accordance with the nature of the predominating iron-bearing constituent, which occurs along with the plagioclase in porphyritic crystals, into:—

1. MICA-PORPHYRITES, containing biotite as their principal iron-bearing porphyritic constituent, including:—
    - (A) *mica-porphyrite,* which contains no quartz among its porphyritic components.

(B) *quartz-mica-porphyrite,* which contains quartz porphyritically developed.

2. HORNBLENDE-PORPHYRITES, containing hornblende as their most important iron-bearing porphyritic ingredient. According as these contain porphyritic quartz crystals or not, they are divided into:—
    - (A) *hornblende-porphyrite,* quartz-free.
    - (B) *quartz-hornblende-porphyrite,* quartz-bearing.
3. ENSTATITE-PORPHYRITES, containing a rhombic pyroxene as a prominent porphyritic component.

D. THE AUGITE-PORPHYRITES AND MELAPHYRES.

This class corresponds to the gabbros and diabases among the intrusive rocks. Its members consist essentially of plagioclase and augite, and sometimes olivine, idiomorphically developed in a ground mass which may be either holocrystalline, hypocrystalline or glassy. According as the members of this group are olivine-free or olivine-bearing they are divided into:—

1. AUGITE-PORPHYRITES, containing no olivine. This group embraces:—
    - (A) *diabase-porphyrite,* possessing a panidiomorphic- or diabasic-granular groundmass of plagioclase and augite.
    - (B) *spilite,* which is characterized by its fineness of grain and its lack of porphyritic constituents.
    - (C) *augite-porphyrite,* having a fine-grained hypocrystalline ground mass in which are numerous porphyritic crystals of plagioclase and augite. Augite porphyrite includes:—
        - (*c* 1) labradorite-porphyrite, in which the porphyritic feldspar is labradorite and the ground mass is composed of a second generation of augite and lath-shaped crystals of plagioclase and a very little glassy base.
        - (*c* 2) weiselbergite, in which the ground mass is made up of a second and sometimes a third generation of augite and slender needles of plagioclase, arranged in flow lines in a glassy base (*hyalopilitic* structure).

(*c* 3) tholeiite, in which the constituents of the ground mass occur in but a single generation, and the structure is hypocrystalline through the existence of a little glass, which is aggregated in small areas between the crystalline components (*intersertal* structure).

(D) *augite-vitrophyrite,* consisting principally of a glassy ground mass in which are a few microlites of plagioclase, augite and magnetite.

1. MELAPHYRES, consisting essentially of plagioclase, augite and olivine. As in the augite porphyrite proper, three types are distinguished :—

(A) *navite,* an olivine-bearing rock corresponding in structure to labrador-porphyrite.

(B) *olivine-weiselbergite,* with the characteristics of weiselbergite.

(C) *olivine-tholeiite,* an olivine-bearing tholeiite.

E. THE PICRITE PORPHYRITES.

The picrite porphyrites correspond to the intrusive peridotites. They are composed of idiomorphic olivine and augite crystals in a ground mass, which consists principally of a glassy base, which by devitrification often becomes weakly doubly refracting.

The picrite-porphyrites are limited in their distribution. They are characterized particularly by the lack of feldspar in porphyritic crystals.

III. B. THE NEOVOLCANIC EFFUSIVE ROCKS.

The neovolcanic rocks occur principally as lavas, on the surface of the earth, as intercalated layers between sedimentaries, as dykes, volcanic necks and bosses. They are characterized by the vitreous appearance of the feldspars.

They are divided according to their mineralogical composition into families corresponding to those of the intrusive and palæovolcanic classes.

A. THE LIPARITES AND PANTELLERITES.

The liparites and pantellerites are composed essentially of an alkaline feldspar and quartz in porphyritic crystals, together with a ground mass which may be either holocrystalline or glassy.

They are separated according to the nature of their porphyritic feldspathic constituents into liparites and pantellerites.

1. LIPARITES, in which the porphyritic alkaline feldspar is sanidine. These are divided into:—
    - (A) *nevadites*, containing numerous porphyritic crystals and a ground mass whose structure forms the basis for a further subdivision into:—
        - (*a* 1) nevadite, with a holocrystalline ground mass.
        - (*a* 2) felso-nevadite, with a felsitic ground mass.
        - (*a* 3) hyalo-nevadite, with a glassy ground mass.
    - (B) *liparites*, containing few porphyritic crystals, and these few almost exclusively sanidine. These include:—
        - (*b* 1) liparite, with a holocrystalline ground mass.
        - (*b* 2) felso-liparite, with a felsitic ground mass.
    - (C) *hyalo-liparite*, a glass with the composition of liparite, containing microlitic inclusions of sanidine, quartz and the iron-bearing silicates.
2. PANTELLERITES, in which the porphyritic constituent is anorthoclase.

B. THE TRACHYTES AND QUARTZLESS PANTELLERITES.

This group is characterized by the predominance of an alkaline feldspar among its porphyritic constituents, and its freedom from quartz. In addition to the feldspar there is usually an iron-bearing mineral porphyritically developed.

Their structure, like that of the other effusive rocks, varies widely, but always tends to the porphyritic.

This group is divided into:—

1. TRACHYTES, in which the porphyritic component is sanidine. The trachytes are next subdivided into:—
    - (A) *trachyte*, with a holocrystalline to hypocrystalline ground mass.
        - (*a* 1) mica-trachyte, with sanidine and biotite as the most prominent porphyritic constituents.
        - (*a* 2) augite-trachyte, in which augite replaces the biotite of (*a* 1).
    - (B) *phonolitic trachytes*, differing from trachyte proper principally in the possession of the characteristic minerals of phonolite, viz., ægirine, acmite and sodalite. They include:—
        - (*b* 1) sodalite-trachyte, which is rich in minerals of the sodalite group.

(*b* 2) acmite trachyte, in which the amphiboloids are acmite, ægerine and arfvedsonite.

(C) *andesitic trachytes*, with a hyalopilitic ground mass tending strongly to a glassy development.

(*c* 1) biotite-hypersthene-trachyte, containing biotite, hypersthene, augite and sanidine in a glassy ground mass.

(*c* 2) the Arso type, in which sanidine and augite are the principal porphyritic minerals, and the ground mass is hypocrystalline.

(D) *hyalo-trachyte*, consisting principally of glass, with the composition of trachyte.

2. QUARTZLESS PANTELLERITES, have anorthoclase and iron-bearing minerals as porphyritic constituents.

C. THE PHONOLITES.

The phonolites embrace the quartz-free combinations of an alkaline feldspar with the minerals of the nepheline and leucite groups, and usually a monoclinic augite.

They include:—

1. PHONOLITES PROPER, containing nepheline and feldspar as the essential porphyritic constituents, as well as the essential components of the ground mass, which is holocrystalline, hypocrystalline, or glassy.

(A) *trachyte-phonolite*, in which sanidine predominates over the nepheline, particularly in the ground mass.

(B) *nephelinite-phonolite*, in which nepheline predominates over the feldspar.

(C) *hyalo-phonolite* or *Phonolite Glass*, a glass with the composition of phonolite, containing microlites of sanidine and augite.

2. LEUCITE-PHONOLITES, containing leucite instead of nepheline among the porphyritic constituents.

3. LEUCITOPHYRES, containing both leucite and nepheline in addition to sanidine.

D. THE DACITES.

The dacites are quartz-bearing plagioclase rocks. They contain, also, one of the iron-bearing minerals of the biotite, amphibole or pyroxene groups.

Their structure varies widely in consequence of the fact that they occur at considerable depths within the earth, and are moreover very sensible to chemical alteration. They are separated, according to their structure, into:—

- (A) *holocrystalline dacites,* with many or few porphyritic constituents.
- (B) *felsodacites,* with a microfelsitic ground mass.
- (C) *andesitic dacites,* with a hyalopilitic ground mass.
- (D) *vitrophyric dacites,* or *dacite glasses,* with the composition of dacite holding porphyritic crystals of plagioclase, quartz and the iron-bearing silicates.

E. THE ANDESITES.

The andesites are neovolcanic rocks, composed principally of plagioclase and the iron-bearing silicates of the biotite, amphibole and pyroxene groups, thus corresponding to the porphyrites of the palæovolcanic group, and the diorites, and some of the gabbros of the intrusive class.

They are divided, according to the prevalence of one or the other of the iron-bearing silicates among the porphyritic constituents, into:—

1. MICA-ANDESITES, in which biotite predominates over the other iron-bearing minerals. They are subdivided, according to the structure of their ground mass, into:—
    - (A) *holocrystalline mica-andesites.*
    - (B) *felsodacitic mica-andesites.*
    - (C) *mica-andesites proper.*
    - (D) *trachytic mica-andesites.*
    - (E) *vitrophyric mica-andesites.*
2. HORNBLENDE-ANDESITES, in which hornblende predominates. These are subdivided as are the mica andesites.
3. AUGITE-ANDESITES, in which a monocline augite is the prevailing iron-bearing porphyritic constituent. Subdivided like the mica-andesites.
4. HYPERSTHENE-ANDESITES, in which a rhombic instead of a monoclinic augite is the prevailing porphyritic constituent. Subdivided like the mica-andesites.
5. HYALOANDESITES, or ANDESITE GLASSES, glasses with the com-

position of andesite, containing a few microlites corresponding to the porphyritic components of the andesite group.

F. THE BASALTS.

The basalts are composed essentially of a plagioclase feldspar and augite, with or without olivine. They differ from the andesites in the predominance of augite over biotite and hornblende, and are thus the equivalents of the diabases.

They possess a wide range of structure, from the hypidiomorphic-granular to the glassy.

They are separated into two great divisions, distinguished by the presence or absence of olivine.

1. OLIVINE-FREE BASALTS, containing plagioclase and augite in a hypocrystalline ground mass.
2. OLIVINE BASALTS, in which olivine is an essential constituent, in addition to plagioclase and augite. Among the olivine basalts are included:—
    - (A) *hypersthene basalt*, with an orthorhombic augite as one of the porphyritic constituents.
    - (B) *quartz basalt*, with corroded quartzes among the augite, olivine and plagioclase of the first generation.
    - (C) *hornblende basalt*, with brown hornblende as a porphyritic ingredient.
4. HYALOBASALTS, or BASALT GLASSES, glasses with the composition of basalt, containing microlites of augite, plagioclase and olivine.

G. THE TEPHRITES AND BASANITES.

The tephrites and basanites contain as essential constituents a basic plagioclase and nepheline or leucite, or both. The former are olivine-free, the latter olivine-bearing.

They differ from the phonolites in the nature of their prevalent feldspar.

Their most common structure is the holocrystalline porphyritic

1. THE TEPHRITES are the olivine-free varieties. They are subdivided, like the phonolites, into:—
    - (A) *nepheline-tephrite*, in which nepheline occurs generally as a constituent of the ground mass, but occasionally also in porphyritic crystals.

(B) *leucite-tephrite,* in which leucite replaces the nepheline of the tephrite.
(C) *leucite-nepheline-tephrite,* containing both nepheline and leucite.

2. BASANITES contain olivine as an essential constituent. The olivine is almost always present in porphyritic crystals.

   The basanites are subdivided, like the tephrites, into:—

   (A) *nepheline-basanites.*
   (B) *leucite-basanites.*
   (C) *leucite-nepheline-basanites.*

H. THE LEUCITE ROCKS.

The leucite rocks are unique, in that they occur only in the younger effusive series. They contain leucite instead of feldspar as their principal component. With this is always associated augite, and frequently biotite. The occurrence or non-occurrence of olivine serves as a means of separating them into two divisions:—

1. LEUCITITE contains no olivine. Its structure is panidiomorphic- to hypidiomorphic-granular, although it occasionally becomes porphyritic through the development of leucite and augite in two generations.
2. LEUCITE-BASALT contains olivine. Both olivine and augite usually occur in porphyritic crystals, leucite rarely or never. Their structure is porphyritic.

I. THE NEPHELINE ROCKS.

Like the group of the leucite rocks, the present group, which embraces rocks composed principally of nepheline and augite, has no equivalent among the intrusives or the palæovolcanic class.

The prevailing structure is the porphyritic with the iron-bearing silicates and olivine, when it is present, and sometimes nepheline as the porphyritic constituents, while the ground mass is hypocrystalline, and made up in large part of nepheline.

The nepheline rocks are separated into two divisions:—

1. NEPHELINITES, which contain no olivine. These are subdivided, according to structure, into:—

   (A) *doleritic nephelinites,* which are coarse hypidiomorphic granular varieties.

(B) *basaltic nephelinites*, usually porphyritic, with less nepheline and more augite than the doleritic varieties.

(C) *phenolitic nephelinites*, porphyritic varieties with nepheline in two generations and a light-colored augite (acmite) only in the ground mass.

(D) *camptonitic nephelinites*, porphyritic varieties with a base composed principally of nepheline or a glass with the composition of this mineral, and numerous porphyritic crystals of augite and hornblende, sometimes in two generations.

2. NEPHELINE–BASALTS, olivine-bearing. The prevailing types are those corresponding to the doleritic and basaltic nephelinites.

J. THE MELILITE ROCKS.

Melilite rocks are also confined to the neovolcanic class. They have no representatives among either of the other classes. They consist essentially of melilite, olivine and augite.

Their normal structure is the holocrystalline porphyritic, in which olivine, augite and biotite, and sometimes melilite, occur in two generations, although the last-named mineral is more commonly found only in the groundmass.

The separation of the group into two varieties:—

(A) *melilite-basalts*, and

(B) *alnöites*, rests almost entirely upon geological grounds. The alnöites, however, are much richer in augite than the melilite basalts, and also contain more biotite.

K. THE LIMBURGITES AND AUGITITES.

This group includes rocks composed in larger part of pyroxene, with or without olivine. They usually contain also a little plagioclase and hornblende.

Their normal structure is the hypocrystalline porphyritic, though sometimes they become completely amorphous through the absence of porphyritic constituents.

They are divided into:—

1. LIMBURGITES, which are olivine-bearing, and
2. AUGITITES, which are olivine-free.

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